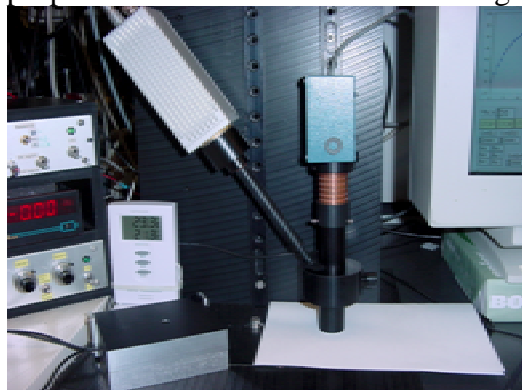


TOOLS FOR DETECTION OF PHOTOTROPHIC AND CHEMOSYNTHETIC MICROBIAL LIFE ON MARS

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An evaluation of the highest probability approaches most suitable for revealing microbial life on Mars is the main focus of this project. Two signatures of microbial life are proposed as targets for characterization in future Mars rover missions: 1) all natural photosynthetic life on earth exhibits a time-dependent adaptation to illumination over the micro-milli-second interval that serves as a unique signature of phototrophic life, and 2) the inter-conversion of disequilibrium in redox potentials of environmental constituents serves as the principal chemosynthetic energy source in the metabolism of heterotrophic bacteria. A top priority of our work is the development of tools for the unambiguous detection and quantitative estimation of these markers on Mars.

A laser-based fluorescence induction spectrometer suitable for remote sensing (100 meters radius via telescope) of variable fluorescence and luminescence emission intensity and spectrum (near UV through near IR) from organic chromophores including photosynthetic pigments and organophosphates (nucleic acids, ATP, FAD, NAD, NADP and their degradation products) is proposed. This scouting tool shall increase the local prospecting probability by enabling a rover to prescreen candidate sites for detailed sample acquisition and analysis. Sampling of ice, rock and airborne particles will be employed. For airborne particles, natural fractionation occurs in air that separates particles of light organic matter from dense mineral phases and shall be employed for enrichment of light matter suitable for high sensitivity analysis. The detection of temporal changes in fluorescence emission intensity upon changes in light excitation intensity (light adaptation) will be an integral part of this spectrometer. Microbial organisms respond to changes in electrochemical potential by altering the redox state of their constituent energy cofactor molecules. This change has been detected in phototrophs using light to initiate redox change and fluorescence emission to detect the redox state (variable fluorescence). It has a characteristic time/light response that differs from abiotic fluorescence or luminescence and is a unique signature of life. Two prototypes of the above spectrometer have been built and tested. The proposed instrument would be a third generation instrument suitable for Mars missions.



Microbes are masters at exploiting gradients in chemical potential to derive energy for growth. They do this by inter-conversion of molecules that have different chemical potentials owing to their different chemical structures or concentration gradients across interfaces. The atmosphere of Mars is exposed to high levels of UV radiation producing O_2 and radical O gaseous species. At the Martian surface these species create an oxidized layer of unknown extent, but a substantial vertical gradient in this electrochemical

potential must exist. Measurement of the magnitude and chemical form (speciation) of this O_2 /redox disequilibrium using ultra-sensitive electrochemical and fluorescence techniques suitable for measurement of O_2 concentrations shall be compared. Supported by NAI.